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FIRE

CHAPARRAL VEGETATION TYPE

Division of Range and Wildlife
Southwestern Region
Forest Service
April 1970

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UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE

June 4, 1970

REPLY TO: 2520 Watershed Protection and Management (4300)

SUBJECT: Kellner Canyon - Russell Gulch Project and SW Region Chaparral Program

TO: Frank J. Smith, Asst. Regional Forester
Range & Wildlife Management
Albuquerque, N.M.

Dear Frank:

Thanks for the opportunity to review the Range and Wildlife Division's "Chaparral vegetation type" publication. You have covered quite a wide swath in this, and I am sure this will be of considerable assistance in preparation of management plans and otherwise establishing a reasonably uniform policy of use.

I realize that this is still preliminary to final preparation and adoption, so in my review I have taken the liberty to note certain typographical errors, as well as to point out areas I feel need further clarification. Many of these you have, no doubt, already corrected. We don't have the final word on much of this, so you can consider my suggestions for what you think they are worth. As new published work becomes available on chaparral ecology and management in Arizona, I suspect you will feel the need to make further revisions. In the meantime, I think you've done a good job in compiling this publication.

My comments are attached.

CHARLES P. PASE
Plant Ecologist

Attach.

Page 1, line 9. "Spring moisture" is very deficient in this type in general - in fact, this is our driest season. The main criterion is winter rainfal-summer rain helps, but is not characteristic of Mediterranean vegetation.

Page 1, line 12. Rearrange sentenc to remove implication that the best development of chaparral occurs at Sierra Ancha.

Page 2, line 2. Suggest replace sentence with something like this: Probably less than three percent of the type has burned over within the past 20 years. The burned areas have resulted in....

Page 2, add to par. 2: "(3) the chaparral complex is uniquely adapted to particular climatic and edaphic conditions, and its component species have been selectively "sorted" for tolerance to repeated though infrequent fires." This is actually a third theory, holding that major control of the getation type we call Arizona chaparral is primarily climatic, but it is highly tolerant of fire due to repeated "sorting" probably as far back as the Oligocene or ev late Miocene.

Page 2, par. A. Change wording to indicate both species of manzanita are included here. Add to last sentence of paragraph " "should the fires be closely enough spaced".

Page 2, par. B. Add sentence: It is frequently associated with manzanita in early post-fire succession.

Page 2. par. C. I am not sure the last sentence is correct. The plant is short-lived, and produces seed in the second or third year. It might be ~~different~~ route to eliminate by burning; however, it is relatively susceptible to chemical control.

Page 3, last par. This and the following paragraph apply to Floyd Pond's work at Natural Drainages. I sugg st you preface this paragraph somewhat like this: Chaparral on two distinct soil types was chemically controlled at the Sierra Ancha Experimental Forest in 1954....

Page 4, legend: Calliandra

Page 5 (spelling) Bombycilla
Pipilo chlorurus instead of Chlorura chlorura
Pipilo fuscus ~~Chlor~~

Page 20.	Basalt-drived soils are listed here with "light-textured" soils, while in fact aren't basalt-derived soils rather heavy*? If they are included in this section, I think paragraph 6 should be modified in some way, for these soils produce only a depauperate form of chaparral.
Page 20, par. 5.	What is the sulfate content in runoff water here?
Page 21, 1st par.	The thought here suggests that fire might restrict chaparral from maintaining itself, contrary to page 2.
Page 21, par. under A2	Good quality water is yielded from Barkerville, for which we have data--e.g., sulfate content 20 to 40 ppm.
Page 22, par. 2.	If heavily grazed, fire is not a serious problem. Fires likely won't occur unless grazing is light enough to permit a grass fuel buildup.
Page 22, par. 5.	On such soils, quality of water might be good, but quantity certainly would not, as the tighter soils restrict downward movement and hence lower water yield.
Page 24, par. 1.	This paragraph implies a forest climax of some type, rather than chaparral. Where such soil and climatic conditions are marginal for forest, one would expect succession to be slow and erratic, and easily held in a subclimax phase.
Page 2, line 3.	Hand application.
Page 26, Item 3 at bottom of page	Add "Burning Lehmann lovegrass in February has been successful at Three Bar, resulting in good shrub sprout topkill and low lovegrass mortality."
Page 27, par. 1.	On suitable areas, the costs of rootplowing may still be lowest in the long run--with less hazard from erosion, chemicals, fire escapes, and lower maintenance because of good shrub kill. A good grass seedbed improves seeding success, too.
Page 33, par. 3.	Replace last sentence with: "Fenuron is a broad-spectrum herbicide, and will kill grass as well as forbs and shrubs. At high application rates (12 to 16 lbs. active per acre), it can be expected to inhibit grass establishment for up to 18 months after application."

Page 36, par. 4.	This should be hedged somewhat. The Summit and Three Bar lovegrass stands are still vigorous after 16 and 10 years, respectively, in the absence of grazing.
Page 36, line 23.	(Lavin and Pase, 1963).
Page 36, line 4 from bottom	Slough
Page 43.	Lillie, Donald T.

CHAPARRAL VEGETATION TYPE

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CHAPARRAL VEGETATION TYPE

INTRODUCTION

Between 5-1/2 and 6 million acres of the Southwestern Region are covered by the chaparral vegetation type. Elevations vary from 3,600 to 6,500 feet between the lower, drier southern desert shrub formation and the ponderosa pine-Douglas fir at the higher elevations. Precipitation ranges from 16 to 25 inches with approximately 45 percent falling during the summer and 55 percent in winter (Pase, 1966). Shrubs often root to a depth of 33 feet or more (Pase et al, 1967).

Chaparral closely resembles a Mediterranean vegetation type in that it requires fall and early winter moisture as well as spring moisture. The areas occupied by chaparral in the Southwestern Region are characterized by rainfall at these two seasons of the year.

Chaparral reaches its best development at Sierra Ancha Experimental Forest on diabase - derived soils between 4,500 and 6,000 feet elevation. Where soils are thin, overlying massive unfractured quartzite, chaparral stands become more open with interspersed islands of grassland and forbs (Pase and Johnson, 1968).

With few exceptions, characteristic chaparral shrubs are evergreen, broad sclerophylls. Most have deep, extensive root systems and the ability to resprout vigorously after fire. The few non-sprouting shrubs produce abundant seeds which germinate readily after fire (Page, 1965).

The most extensive and continuous forests of chaparral occur on the southern side of the main ponderosa pine body where the mountain slopes drop away to lower elevations and higher temperatures. Smaller bodies of typical chaparral growth are found throughout southern and eastern Arizona on the slopes of the isolated mountain ranges, occurring above the grass and below the ponderosa pine. Chaparral is characterized by shrubs and stunted trees, much of the cover being so dense it is impenetrable to man or horse. Differences in soils, elevations, and exposures produce differences in the floral structure and dominance. Many areas can only be described as a heterogeneous association. More than one or two species dominate the type to give it a specific character (Nichol, 1937).

PLANT ECOLOGY

Various writers have suggested that chaparral as a vegetation type has not increased in acreage over the years, rather it has merely thickened and closed in upon itself as a result of disturbance. Overgrazing and periodic wildfires over a period of years have probably been the biggest contributor to this particular process.

Probably less than 3 percent of the type has burned over within the past 20 years.

The burned areas have

Wildfires have periodically swept through the chaparral in the past. Small areas (1-3%) within the type have been burned from once to several times. This has resulted in some very heterogeneous stands of chaparral from the standpoint of composition. Islands of pure stands of individual species such as Arctosaphylos or Ceanothus occur interspersed in large areas of mixed species. Mixed stands also occur having one predominant species, and other stands are similar composition-wise but are highly variable in height class and density.

The chaparral area is a complex ecosystem of highly variable ecotypes and plant communities. It has been stated that chaparral is a structural form rather than a successional stage. There are ~~two~~ 3 prevailing theories concerning the type: (1) That the chaparral vegetation type exists primarily as a fire climax; and (2) that chaparral once existed as a climax on certain sites and as mottes throughout other climaxes, but exists primarily as a dis-climax due to disturbance of the pre-existing climax. (3) The chaparral complex is uniquely adapted to particular climatic and soil conditions, and its component species have been selectively "sorted" for tolerance to repeated though infrequent fires. The second theory has the widest range of acceptance. Leopold (1924) indicates that overgrazing and the inability of the land to carry fire resulted in chaparral moving out of its normal zone into the lower grasslands and upward into the woodland and timber zones.

There are three primary methods of reproduction in chaparral: (1) Root-crown sprouters - the majority of species fall into this category; (2) seed producers - several species fall in this category but those of most interest are Arctoslaphylos, Ceanothus, and Cercocarpus; and (3) root sprouters - the only active root sprouter in the community is Eriodyction.

The great majority of chaparral species are crown sprouters of one intensity or another. Three notable exceptions are:

A. Manzanita - ~~This~~ These species do~~es~~ not produce seed until ~~it is~~ about 15 years of age. After that, however, ~~it is~~ they are very prolific. Manzanitas ~~is~~ are a non-sprouter and an initial hot fire will usually eliminate the growing plants. The seed remains viable for many years in the soil and requires fire and heat for appreciable germination. In a balanced tree-brush-grass community, there is little evidence of manzanita. However, the large quantities of seed lying in the soil may dominate a site following the initial fire. In most cases, the second or third fire kills the thick stand of young seedlings and virtually eliminates the species, should the fires be closely enough spaced.

B. Desert Ceanothus - This species produces seed at about 10 years of age. It is short-lived and dies out in the absence of fire. The seed requires fire and heat for germination. In some cases, seeds lying in the soil have dominated a site following wildfire. It is frequently associated with manzanita in early post-fire stages.

C. Yerba Santa - This species is both a seed producer and a very active root sprouter. Initial burning scarifies the seed and stimulates root sprouting so that the species becomes one of the more abundant plants, or may even dominate the site. This species is also usually eliminated by the second or third burn. — ?.

Research on the ecology of chaparral is practically non-existent. There are numerous publications relating to the effects of fire, chemical herbicides, and wildlife.

Chaparral is probably the most variable vegetation type in that it extends from within the fir type down to the desert-grassland type.

A few of the more predominant species of the chaparral site (McCulloch and Pase, 1963 - 440 plants tentatively identified on the 3-Bar Watershed) are listed below:

BOTANICAL NAME	COMMON NAME
Arctostaphylos pringlei	Pringle manzanita
Arctostaphylos pungens	Pointleaf manzanita
Ceanothus greggii	Desert Ceanothus
Ceanothus integerrimus	Deerbrush
Cercocarpus brevifolius	Hairy Mountainmahogany
Cercocarpus betuloides	Birchleaf Mountainmahogany
Cercocarpus montanus	True Mountainmahogany
Cupressus arizonica	Arizona cypress
Eriodictyon angustifolium	Yerba santa
Garrya flavescens	Yellowleaf silktassel
Garrya wrightii	Wright silktassel
Juniperus deppeana	Alligator juniper
Mimosa biuncifera	Mimosa
Nolina microcarpa	Sacahuista
Pinus edulis	Pinyon
Pinus monophylla	Single-leaf pinyon
Quercus emoryi	Emory oak
Quercus palmeri	Palmer oak
Quercus gambellii	Gambels oak
Quercus turbinella	Shrub live oak
Quercus undulata	Wavy-leaf oak
Rhamnus crocea	Hollyleaf buckthorn
Rhus trilobata	Skunkbush Sumac
Rhus ovata	Sugar sumac
Yucca spp.	Yucca

Soils

Soils are the most important inventory aspect when considering treatment for water yield improvement or land treatment practices.

Chaparral on two distinct soil types was chemically controlled at Sierra Ancha Experimental Forest in 1954

Soils derived from quartzite were shallow and contained considerable amounts of clay. Islands of grass were present in the chaparral on this soil before treatment. Following shrub control with herbicides, the cover of all understory vegetation on quartzite soil increased, but increase in grass cover was quickest and most spectacular. Half shrubs and forbs increased less rapidly, but continuously. Increase in grass production was also greater on this soil (Pond, 1964).

Soils derived from diabase were deep and sandy. They supported no islands of grass in the chaparral. Here, half-shrubs increased greatly in cover and production following control of overstory shrubs. Grasses showed little, if any, response, while forbs increased in cover somewhat more than on quartzite soils (Pond, 1964).

The disjunct distribution, reproduction, and rooting habits of Quercus turbinella in the Arizona chaparral were studied on quartz diorite, sedimentary, and volcanic substrata. The oak was less dense on the sediments and volcanics than on quartz diorite. Lower densities on the bedded sediments resulted from restricted root penetration which prevented access to deep soil moisture. On the volcanic substratum, heavy clay soils gave an overall poorer moisture regime than soils developed from the quartz diorite. Shrubs growing on the less favorable sedimentary and volcanic substrata probably were more susceptible to damage by drought and fire, and low mobility and low seedling production tended to eliminate the species from these areas. It is suggested that the Q. turbinella "islands" within large areas of grassland are relics rather than evidence of invasion (Saunier and Wagle, 1967).

ANIMAL ECOLOGY

A discussion of how wildlife populations fit into the ecology of a chaparral area must be prefaced by the understanding of how plant succession and interspersion of types affect wildlife habitat.

Quotations from Aldo Leopold's book "Game Management" appears to give us the background understanding needed. Wildlife species fit into an ecological scale pattern, just as plants do. A few species are definitely associated with all stages including climax; but as Mr. Leopold clearly points out - "A MAJORITY OF GAME SPECIES ARE ASSOCIATED WITH AN INTERSPERSION OF THE EARLY AND INTERMEDIATE STAGES OF PLANT SUCCESSION."

To explain the importance of interspersion of types, Leopold compares man's need for interspersion with that of wildlife.

> "A city includes all of the environmental (types) which human animals require for thrift and welfare. If, however, all the kitchens were situated within one quarter of a given city, all the bedrooms in another quarter, all the restaurants and dining-rooms in a third, and all the parks and golf courses in the last quarter, the human population which it would be capable of supporting would be considerably reduced. The extent of the reduction would vary inversely to the mobility of the inhabitants. In fact, it is only the recent artificial extension of the human cruising radius by means of mechanical transportation that would allow such a city to be inhabited at all.

> Likewise with game. The game must usually be able to reach each of the essential types each day. The maximum population of any given piece of land depends, therefore, not only on its environmental types or composition, but also on the interspersion of these types in relation to the cruising radius of the species. Composition and interspersion are thus the two principal determinants of potential abundance on game range."

In explaining the law of interspersion, Leopold states "Game is a phenomenon of edges. It occurs where the types of food and cover which it needs come together, i.e., where the edges meet. We do not understand the reason for all of these edge effects, but in those cases where we can guess the reason, it usually refers back either to the desirability of simultaneous access to more than one environmental type, or the greater richness of border vegetation, or both."

Game populations are quite low, especially in dense, unbroken chaparral. White tailed deer (Odocoileus virgenianus covesi) and mule deer (Odocoileus hemionus), the most important big game animals, may occur at a density of only 10 per square mile where herbaceous cover or palatable shrubs are sparse (Pase, et al, 1967).

Locally in Arizona chaparral, deer populations vary from 20 to 30 per square mile to 4 to 5 per square mile. The high populations invariably are found in what is designated as the mixed shrub type. This type is dominated by turbinella oak, but contains a good quantity of other plants high in palatability and in nutritive value. Mountainmahogany, desert ceanothus, and hollyleaf buckthorn make up as much as 35 percent of the tall shrub layer. The low population levels usually are found in what is known as the turbinella oak-skunkbush type where the two species, turbinella oak and skunkbush, make up practically the entire shrub cover. Plants of high nutritive value and palatability occur sporadically or not at all. Taking Arizona chaparral as a unit, the deer density has been calculated at only 10 per square mile. The population is kept at this low level due to a shortage of herbaceous material and the occupancy of the area by dense unbroken stands of turbinella oak, skunkbush, manzanita, sugar-sumac, and other nonpalatable shrubs which are low in nutritive value (Swank, 1958).

Palatability of most chaparral shrubs for domestic livestock is thought to be low. Of the major dominants, shrub live oak is taken to a limited extent, especially the sprouts after a fire. Skunkbush, sugar-sumac, birchleaf mountainmahogany, and Emory and Arizona oak are little used by domestic livestock or game, except for fruits. A number of species, noteworthy among which are deerbrush, hollyleaf buckthorn, desert ceanothus and true mountainmahogany, are relished by both livestock and game, and chaparral stands with fair amounts of these species are considered desirable range, especially for deer (Swank, 1958).

Studies of foods used by deer suggested the need for a variety of vegetation types within each animal's home range. Neither mule nor white-tailed deer relied yearlong on a single life form, let along a single species of food plant, but there were certain food classes which appeared more important than others during a given season. There were apparent dietary differences between the two deer species, although there was a degree of overlap in food species used just as there is overlap in use of areas (McCulloch, 1964).

Acorns, beans, berries, forbs, and foliage with young twigs of low and tall shrubs were much eaten by deer, although they notably avoided certain plant species which were abundantly available and potentially edible (McCulloch, 1964).

Shrub live oak, birchleaf mountainmahogany, and Wright silktassel of the Arizona chaparral grew in spring until soil moisture was exhausted. Additional, but a lesser amount of growth was made on summer rainfall. Although there was some variation among species, moisture, crude protein, and phosphorus were highest in early spring and, except for slight summer increases, gradually decreased in later seasons, sprout use was heaviest during late spring when herbaceous vegetation was mostly dry, with mountainmahogany preferred. Sprout selection was associated with high moisture and crude protein, low crude fiber, and a comparatively wide calcium-phosphorous ratio (Reynolds, 1967).

Herbicide treatment to suppress brush regrowth after wildfire depleted the principal foods selected by deer during fawning and start of the nursing season. The treatment greatly increased grasses of which most deer ate but little in proportion to the general availability of grasses. Chemical brush control on a small area (76 acres) left it as attractive to deer as one untreated area, at least during some seasons of the year, and more attractive than some other untreated areas, despite adverse treatment effect on one seasonal food source (McCulloch, 1964).

Pellet group distribution patterns indicated localized site preferences of deer within the untreated chaparral vegetation type and also within a herbicide treated area. These apparent preferences were not generally associated with particular slope factors nor with presence of single shrub species (McCulloch, 1966).

Blacktailed deer populations were studied under three different conditions of chamise brushland: (1) Heavy brush cover protected from fire; (2) wildfire burn; and (3) opened brush, consisting of an interspersion of grass with patches of dense brush. Number of deer in the heavy brush averaged 10 to 30 to the square mile; in the wildfire burn 5 to 160; and in the opened brush about 40 to 110. Populations in the heavy brush and opened brush were rather stable; but in the wildfire burn large numbers of deer moved in when the sprouts were young and tender and out during

cold weather. In adult does the ovulation rates were: Heavy brush 84 percent, wildfire burn 116 percent; opened brush 147 percent. Ratios of fawns to 100 does following the rut were: Heavy brush about 60 to 85; wildfire burn 100 to 110; opened brush 115 to 140 (Biswell, et al, 1952).

A. Cover Requirements: The Black Canyon Highway in Arizona is the main dividing line between the three principal deer. To the north and west are found the Rocky Mountain mule deer. To the east and south are found the Desert mule deer and the white-tailed deer. Consequently, in the chaparral on the Prescott National Forest we have the Rocky Mountain mule deer. On the Tonto a mixture of Desert mule deer and white-tailed deer is found. And, on the Coronado the white-tailed deer, Desert mule deer, and Rocky Mountain mule deer are all found.

Chaparral is occupied yearlong by resident populations of both mule and whitetailed deer, but here again, climate may force increased use of the type under certain conditions.

Bear are generally found in the upper limits of the chaparral. They spend a large portion of their time on north slopes where height and density of cover is more to their liking.

Turkeys are rare or absent in the "interior" chaparral, but are found in the tree-like chaparral around the more watered sites. Band-tailed pigeons are found here also.

Although there are exceptions when antelope, javelina and Gambel quail occupy the chaparral, they are principally found in the fringe areas. When this area is converted to grass, dove move in, in large quantities. Dead chaparral serves as roosting places and most conversions have large quantities of weeds which provide food.

It would be well to discuss the cover requirements and forage conditions of the chaparral in general from a wildlife standpoint.

Actual cover requirements of these species are unknown, but the white-tail appear to be better adapted to the heavy cover than the mule. White-tailed deer do make heavy use of the opening in the 3-Bar study, but the way mule and white-tail use the chaparral type, it is reasoned that white-tail utilizes a heavier cover to opening ratio than the mule deer.

The cover opening ratio or "edge" as defined by Leopold is extremely important as is the varied ecological successional stages the vegetative type must go through from controlled burning back to maturity. This importance is difficult to define, but is very real.

Based on the above, our best estimate is that in white-tail range, up to 50 percent of the type could be treated, while in mule deer range, up to 70 percent could be treated provided suitable leave patterns were

included. These figures are based on the assumption that the pattern of treatment would call for maximum "edge." We should recognize that such treatment may be detrimental to the cover requirements of black bear, but again proper conversion patterns can be helpful in minimizing the impact.

Wildlife benefits of this program can be amplified if the type can be forced to undergo continued change. The opposite will be true if the objective is to maintain the converted acreage in another type without allowing for the successional stages (Tables 1 and 2, Figure 1).

B. Browse Condition: The composition, density, vigor and availability of forage are important items in the chaparral. These items collectively comprise browse condition and may be determined through transect evaluation.

One final wildlife problem that relates to the chaparral type in general is access. This does not necessarily refer to road access, but rather to the hunter's ability to "hunt" the area. Under untreated conditions, only a minor acreage of the chaparral can be hunted. This situation can be greatly improved through proper management of the type.

Table 1. Seasonal variations in relative volumes of foods in mule deer rumens, Three Bar Wildlife Area. 1/ (McCulloch, 1964)

Foods	Stage of Deer Life Cycle	Fawning and Nursing; Antler Growth	Nursing and Weaning	Pre-Breeding Period	Breeding	Early Gestation	Late Gestation; Antler Growth
	Season	Mid-Summer	Early Fall (warm)	Late Fall (cool)	Mid-Winter	Late Winter-Early Spring	Late Spring Early Summer (dry)
		%	%	%	%	%	%
Tall Shrub Fruits		69	0	t	No Records	0	No Records
Forbs		5	6	4	No Records	63	No Records
Low Browse		7	63	23	No Records	11	No Records
Tall Browse		9	16	49	No Records	15	No Records
Grasses		t	t	4	No Records	2	No Records
Miscellaneous		3	0	2	No Records	0	No Records
Unidentifiable Mass		7	15	18	No Records	9	No Records
Total		100	100	100	No Records	100	No Records
		(7)	(21)	(45)	(0)	(5)	(0)

1/ Number of examined rumens indicated in parentheses.

Table 2. Seasonal variations in relative volumes of foods in whitetailed deer rumens, Three Bar Wildlife Area. 1/ (McCulloch, 1964)

Foods	Stage of Deer Life Cycle	Fawning and Nursing; Antler Growth	Nursing and Weaning	Pre-Breeding Period	Breeding	Early Gestation	Late Gestation; Antler Growth
	Season	Mid-Summer	Early Fall (warm)	Late Fall (cool)	Mid-Winter	Late Winter-Early Spring	Late Spring-Early Summer (dry)
		%	%	%	%	%	%
Tall Shrub Fruits		76	No Records	2	No Records	0	No Records
Forbs		4	No Records	39	No Records	27	No Records
Low Browse		3	No Records	28	No Records	8	No Records
Tall Browse		9	No Records	15	No Records	32	No Records
Grasses		t	No Records	4	No Records	6	No Records
Unidentifiable Mass		8	No Records	22	No Records	27	No Records
Total		100	No Records	100	No Records	100	No Records
		(5)	(0)	(10)	(0)	(9)	(0)

1/ Number of examined rumens indicated in parentheses.

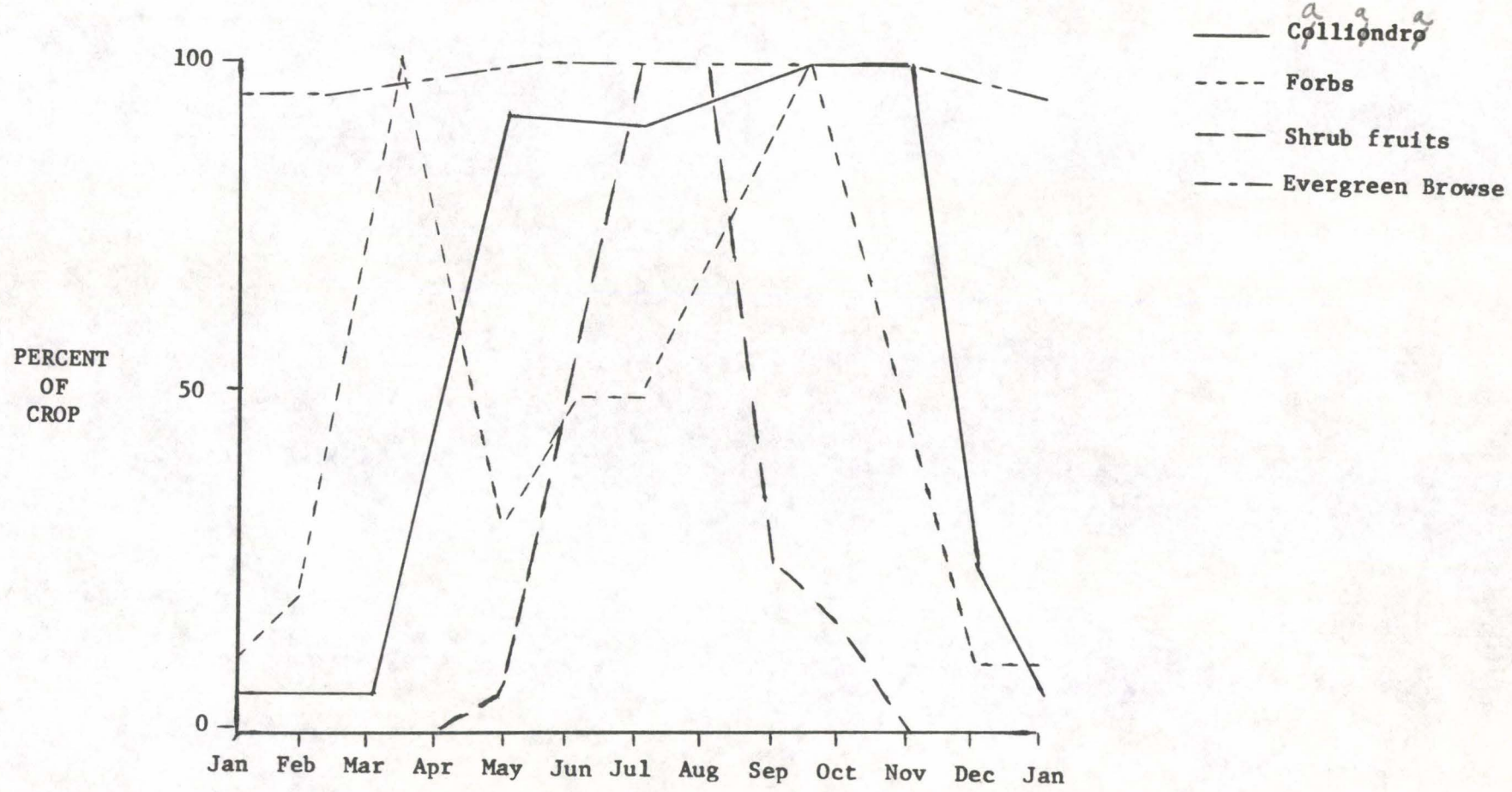


FIGURE 1. SEASONAL AVAILABILITY OF MAJOR DEER FOODS, THREE BAR AREA (McCULLOCH, 1967)

A list of reptiles, birds, and mammals that have been observed in the chaparral vegetation type are: (Reynold and Johnson, 1965)

SCIENTIFIC NAME	COMMON NAME
REPTILES	
Gekos (Gekkonidae)	
Coleonyx variegatus (Baird)	Banded gecko
Iguanas (Iguanidae)	
Crotaphytus collaris (Say)	Collared lizard
Holbrookia texana (Troschel)	Greater earless lizard
Sceloporus clarki (Baird and Girard)	Clark's spiny lizard
Sceloporus undulatus (Latreille)	Eastern fence lizard
Uta ornata (Baird and Girard)	Tree lizard
Phrynosoma douglassi (Bell)	Short-horned lizard
Lateral fold lizards (Anguidae)	
Gerrhonotus kingi (Gray)	Arizona alligator lizard
Beaded lizards (Helodermatidae)*	
Heloderma suspectum (Cope)	Gila Monster
Teids (Teidae)	
Cnemidophorus tigris (Baird and Girard)	Western whiptail
Cnemidophorus sacki (Wiegmann)	Spotted whiptail
Skinks (Scincidae)	
Eumeces obsoletus (Baird and Girard)	Great Plains skink
Blind snakes (Leptotyphlopidae)	
Leptotyphlops humilis (Baird and Girard)	Western blind snake
Colubrids (Colubridae)	
Thamnophis eques (Reuss)	Mexican garter snake
Masticophis bilineatus (Jan.)	Sonora whipsnake
Masticophis taeniatus (Hallowell)	Striped whipsnake
Salvadora grahamiae (Baird and Girard)	Mountain patch-nosed snake
Pituophis catenifer (Blainville)	Gopher snake

*On the rare and endangered species list.

Lampropeltis pyromelana (Cope)	Sonora mountain kingsnake
Hypsiglena torquata (Gunther)	Night snake
Tantilla atriceps (Gunther)	Mexican black-headed snake
Pit vipers (Crotalidae)	
Crotalus molossus (Baird and Girard)	Black-tailed rattlesnake
Crotalus viridis (Rafinesque)	Western rattlesnake

BIRDS

American vultures (Cathartidae)	
Cathartes aura (Linnaeus)	Turkey vulture
Hawks, old-world vultures and harriers (Accipitridae)	
Accipiter gentilis (Linnaeus)	Goshawk
Buteo jamaicensis (Gmelin)	Red-tailed hawk
Quails, pheasants, and peacocks (Phasianidae)	
Lophortyx gambelii (Gambel)	Gambel's quail
Cyrtonyx montesumae (Vigors)	Harlequin quail
Turkeys (Meleagridioae)	
Meleagris gallopavo (Linnaeus)	Turkey
Pigeons and doves (Columbidae)	
Columba fasciata (Say)	Band-tailed pigeon
Zenaidura macroura (Linnaeus)	Mourning dove
Roadrunners (Cuculidae)	
Geococcyx californianus (Lesson)	Roadrunner
Typical owls (Strigidae)	
Otus asio (Linnaeus)	Screech owl
Bubo virginianus (Gmelin)	Great horned owl
Micrathene whitneyi (Cooper)	Elf owl
Goatsuckers (Caprimulgidae)	
Caprimulgus vociferus (Wilson)	Whip-poor-will
Phalaenoptilus nuttallii (Audubon)	Poor-will

Swifts (Apodidae)	
Aeronautes saxatalis (Woodhouse)	White-throated swift
Hummingbirds (Trochilidae)	
Archilochus alexandri (Bourcier and Mulsant)	Black-chinned hummingbird
Tyrant flycatchers (Tyrannidae)	
Tyrannus verticalis (Say)	Western kingbird
Tyrannus vociferans (Swainson)	Cassin's kingbird
Myiarchus cinerascens (Lawrence)	Ash-throated flycatcher
Jays, magpies, and crows (Corvidae)	
Cyanocitta stelleri (Gemelin)	Steller's jay
Aphelocoma coerulescens (Bosc)	Scrub jay
Corvus corax (Linnaeus)	Common raven
Titmice and Bushtits (Paridae)	
Parus gambeli (Ridgway)	Mountain chickadee
Parus inornatus (Gambel)	Plain titmouse
Psaltriparus minimus (Townsend)	Common bushtit
Wrens (Troglodytidae)	
Troglodytes aedon (Vieillot)	House wren
Thryomanes bewickii (Audubon)	Bewick's wren
Catherpes mexicanus (Swainson)	Canyon wren
Salpinctes obsoletus (Say)	Rock wren
Mockingbirds and thrashers (Mimidae)	
Mimus polyglottos (Linnaeus)	Mockingbird
Solitaires (Turdidae)	
Turdus migratorius (Linnaeus)	Robin
Myadestes Townsendi (Audubon)	Townsend's solitaire
Gnatcatchers, and kinglets (Sylviidae)	
Polioptila caerulea (Linnaeus)	Blue-gray gnatcatcher
Regulus calendula (Linnaeus)	Ruby-crowned kinglet

Waxwings (Bombycillidae)

Bonbycilla cedrorum (Vieillot)	Cedar waxwing

Shrikes (Laniidae)

Lanius ludovicianus (Linnaeus)	Loggerhead shrike

Vireos (Vireonidae)

Vireo huttoni (Cassin)	Hutton's vireo
Vireo vicinior (Coues)	Gray vireo

Wood warblers (Parulidae)

Vermivora celata (Say)	Orange-crowned warbler
Dendroica auduboni (Townsend)	Audobon's warbler

Orioles (Icteridae)

Icterus cucullatus (Swainson)	Hooded oriole
Icterus parisorum (Bonaparte)	Scott's oriole
Molothrus ater (Boddaert)	Brown-headed cowbird

Grosbeaks, finches, sparrows, and buntings (Fringillidae)

Richmondena cardinalis (Linnaeus)	Cardinal
Carpodacus mexicanus (Muller)	House finch
Pipilo chlorurus ~~Chlorura chlorura~~ (Audubon)	Green-tailed towhee
Pipilo erythrophthalmus (Linnaeus)	Rufous-sided towhee
Pipilo fuscus (Swainson)	Brown towhee
Junco hyemalis (Linnaeus)	Slate-colored junco
Spizella atrogularis (Cabanis)	Black-chinned sparrow
Zonotrichia leucophrys (Forster)	White-crowned sparrow

MAMMALS

Bats (Chiroptera)

Myotis keeni (Merriam)	Northern brown bat
Myotis californicus (Audubon and Bachman)	California brown bat
Myotis subulatus (Say)	Masked brown bat

Pipistrellus hesperus (Allen)	Western pipistrelle
Eptesicus fuscus (Beauvois)	Big brown bat
Tadarida mexicana (Saussure)	Mexican freetail bat
Rodents (Rodentia)	
Sciurus aberti (Woodhouse)	Tassel-eared squirrel
Sciurus arizonensis (Coues)	Arizona gray squirrel
Citellus variegatus (Erxleben)	Rock squirrel
Eutamias dorsalis (Baird)	Cliff chipmunk
Peromyscus boylei (Baird)	Brush mouse
Neotoma albigula (Hartley)	White-throated packrat
Flesh-eaters (Carnivora)	
Canis latrans (Say)	Coyote
Urocyon cinereoargenteus (Schreber)	Gray fox
Ursus americanus (Pallas)	Black bear
Bassariscus astutus (Lichtenstein)	Ringtail
Mephitis mephitis (Schreber)	Common striped skunk
Conepatus mesoleucus (Lichtenstein)	Western rooter skunk
Lynx rufus (Schreber)	Bobcat
Even-toed ungulates (Artiodactyla)	
Tayassu tajacu (Linnaeus)	Collared peccary
Odocoileus virginianus (Zimmermann)	Whitetail deer
Odocoileus hemionus (Rafinesque)	Mule deer

EFFECTS OF FIRE ON CHAPARRAL

Chaparral is highly adapted to withstand fire. While it burns readily during periods of high fire hazard, most shrubs sprout vigorously, or have seeds whose germination is greatly increased by heat scarification. After fire, herbaceous cover builds up rapidly, but is typically of short duration as shrub sprouts soon regain dominance (Pase, et al, 1967).

When fire sweeps through a chaparral stand, the plants are killed back to ground level and largely resprout from the root crown. Associated with this initial fire is a tremendous increase in manzanita and ceanothus seedlings (due to scarification of the seeds by fire) and yerba santa (the only active root sprouter). Repeated burning results in a deterioration of the composition of the stand from the standpoint of desirable forage species. Ceanothus and Arctostaphylos are the first to be destroyed and are virtually non-existent after the second or third hot fire. Cercocarpus and Rhus, both of which are weak crown sprouters, are the next to go. The intermediate crown sprouters (Garrya) and Rhamnus die out next. Oak (Quercus) is the strongest sprouter and would be the major species to survive. Repeated burning over an extended period of time would tend to convert a mixed chaparral site to a pure stand of oak, mimosa, yucca or a combination of any or all of these plants (Pase, 1970). Fire resulted in more brush seedlings and sprouts and better range for deer. However, fire must be used judiciously or the nonsprouting species will be diminished in abundance and the carrying capacity may be decreased." (Biswell and Gilman, 1961)

A chaparral fire on the Three Bar watersheds, Tonto National Forest, caused deer use to decline after the burn. Few deer died in the fire, but their food supply was temporarily destroyed. Deer numbers apparently increased on nearby unburned areas (McCulloch, 1960).

The use of fire to break up stands of mature Pringle manzanita may result in seedlings of less desirable species, which may be in part offset by an increase in certain shrubs that are highly desirable as game forage. Additional control techniques to improve the composition of replacement vegetation are badly needed before fire is widely used in such areas (Pase, 1965).

One burn was sufficient to kill most of the old desert ceanothus plants. Seedlings were observed coming in on the burned plots over the years. Also, two of the old plants definitely sprouted on the plots treated at 2-year intervals. These were the only sprouts of this species observed. These were eliminated by the second burn. (Pond and Cable, 1960)

Five years after the burn, sprouting shrubs had regained density that approximated shrub densities on unburned chaparral type. Shrubs most valuable as forage for livestock or game, such as desert ceanothus and hollyleaf buckthorn, constituted only a very small part of the cover. (Cable, 1957)

When a hot fire sweeps through chaparral, the ground cover is virtually destroyed. In the absence of ground cover, the stand will not burn again for a minimum of 20-30 years. This time is required for the establishment of litter cover, twigs, etc., on the ground to carry the fire.

Because of the generally steep slopes, the nature of parent geologic materials, the young immature soils, and the inherent scarcity of herbaceous plant cover, potential sediment movement rates on many chaparral sites are high. (Glendening, 1959).

A chaparral fire can greatly change the functioning of a watershed. Only vestiges remain of the vegetation that has held these mountain soils in place. There is no canopy of interlocking tops of bushes to break the force of driving rainstorms; the scanty remnant of scorched but unconsumed shrub skeletons have but little effect on interception. These charred stems and the incomplete layer of ashes also have little effect in slowing down water running over the surface. (Chapline, et al, 1959)

During the first 21 months after the chaparral cover was burned by wildfire, bedload sediment yields equivalent to 49,839, 21,519, and 64,446 tons per square mile have been measured on 3-Bar experimental watersheds respectively. (Glendening, et al, 1961)

PAST HISTORY

"Historical materials are so diverse in their content that in the hands of an uncritical researcher they may be (and, in fact, frequently are) used to 'prove' whatever the research desires." (Hastings, 1959)

A history of grazing on the Tonto National Forest, prepared in 1926 by Senior Ranger Fred W. Croxen, gives some outstanding accounts of early day vegetation on the Tonto National Forest. This history was developed through personal contacts with 19 early-day cattlemen of which only one was surviving in 1926. Following is a brief summary of the more important facts of this paper. (The complete paper is on file in the Division of Range and Wildlife.)

Interest in central Arizona was not established to any great extent until shortly after the Civil War. The first settlers into the area were basically prospectors, traders and packers who were following the troops. By 1875, the cattle were beginning to show up in the area and numbers were increasing very rapidly.

Sheep started to show up in about 1880. All old timers agreed that the range was fully stocked by about 1890 with a peak in numbers reached in about 1900. In 1926, the statement was made that where there is one cow now, there were 15 to 20 in 1900. As a result of the 1904 drought, cattle numbers were reduced to a much lower level and have <u>never</u> built back up to the point they were prior to the drought.

Descriptions of the vegetation prior to the great herds of cattle all mention the tremendous amount of open grassland with very little brush present. Some quotes from Mr. Croxin's paper are as follows:

> "The Pine Bunchgrass grew all over Sierra Anchas in the pine type and lower down than the pine timber on the North Slopes."
>
> "All the men interviewed state that there was little brush in the country at the time stock was first brought in and it was possible to drive a wagon nearly anywhere one desired."
>
> "Nearly all of the north slope of Mt. Ord was a pine bunchgrass country. At present, this is one of the brushiest pieces of range on the Tonto."
>
> "The influx of Texans and others killed much of the Pine grass by following their former methods of the plains by burning the old mature grass." These individuals were located on Moore Creek, Ellison Creek and the head of the East Verde.
>
> "In summary, 'to quote the last words of Florence Packard when he finished telling me of old time conditions is used - 'The range is not overstocked at present; it is just worn out and gone' and such is the case. While man, the most destructive of animals, brought his herds to a virgin range, only fifty years ago, and abused it in every way he could. We see the result today."

This same document contained a few interesting remarks concerning the status of wildlife during those early days when vegetative types obviously did not resemble the situation we have today. "He says there were beaver in the streams in Tonto Basin in the early days, but they were not trapped out by white men. The floods caused by the denuding of the ranges finally washed them out. There was an occasional wolf in the late 1870's and early 1880's and quite a few lion, but the lions did not bother the stock as deer were very plentiful, deer being the natural animal for them to prey on. He says one could ride from Pine to the East Verde settlement and see deer on every point."

PLANT-SOIL-WATER AND ANIMAL RELATIONSHIPS

For purposes of classification, treatment, use, and water yield, the chaparral vegetation type falls roughly into three very broad plant-soil-water relationship groups. Within any given group there are wide differentiations of height, density, and composition depending upon the degree and depth of soil formation and other ecological factors.

A. Where Chaparral Has Reached or Will Reach Climax. These soils are classified as poor due to weak development or the complete absence of development. They are broken into two categories based on productivity.

A1. Shallow Soils Overlying Fractured Rock. Chaparral soils such as these are: Moano (Schist); Oneida (Metamorphosed shale); Cabezon (Basalt); Venezia (Basalt); and Elledge (Sandstone).

Chaparral as a climax type generally occupies light textured shallow soils overlying deeply fractured parent material. Such a situation precludes eventual dominance by grass due to the plant-soil-water relationship. It also precludes the eventual dominance of tree species due to the above plus the competition of the extensive deep roots of the chaparral species.

Persistence of grass and forbs following good germination and seedling emergence is not good due to the poor soil-water relationship. The grass becomes a sparse stand of wolf plants which lends itself to a rapid re-establishment of chaparral. Grass in even a fair condition cannot persist for an extended period under such conditions and the site reverts back to the better adapted, deep rooted chaparral. Closing in of the overstory canopy is also a factor in the elimination of herbaceous ground cover.

Water yield in this type would be inconsequential. For purposes of wildlife habitat improvement, fires in types A2 or C should be allowed to run through type A1 if thick enough to carry fire. However, no maintenance should be performed on type 1.

The quality of the water would generally consist of great amounts of sediment and appreciable higher sulfate content. Erosion of the soil is more predominant in this type.

Such soils are ideally suited to the production of chaparral. When chaparral is eliminated and grass established, only a scattering of wolf plants will result. Maintaining a poor to fair stand of grass on such sites would require difficult, costly, ineffective and frequent retreatment.

These soils often were the original sites of climax or near climax chaparral. Soil-water relationships were not conducive to the production of a dense grass cover. However, the deep rooted chaparral penetrating the fractured rock enjoyed a much better plant-soil-water relationship and thrived on such sites. These "islands" of chaparral were strategically located for the invasion of the grassland and timber soils following disturbance. Many of these stands existed as open tree type stands which produced little ground fuel and were relatively safe from wildfire, thereby serving as a natural seed source for the surrounding disturbed areas. Other similar stands had soils capable of producing sufficient ground cover to carry a fire where burned over extended periods of time. However, the sprouting chaparral created so much competition with grass that many years were required to build up sufficient ground fuel to carry a fire. These areas also served as a natural seed source for any surrounding disturbed areas.

As the chaparral stand matures, individual plants or small clumps of even-aged plants die out due to (1) old age, or (2) overuse or abuse by animals. On soil conditions such as these, there is little competition allowing a portion of the seed in the soil to sprout and develop into mature plants. Such stands tend to maintain themselves. Decadence and die-out of large portions of chaparral in this type are usually due to a past fire which provided a more uniformly aged stand. Even in the larger die-out areas, the above principles still apply and the stand maintains itself. This suggest that fire might restrict chaparral maintenance, contrary to page 2.

Although the poor water-soil relationship is most devastating to understory vegetation, its toll can also be seen in the height and density of the chaparral itself. Because of this, we can surmise certain wildlife relationships with the type. Availability of browse for forage would generally exceed that in the more productive sites where plants rapidly grow out of animals' reach. Browse composition may rate lower from a deer foraging standpoint because of the general increase of low value browse plants. Cover-wise, when this type occurs on ridges, it is especially important. Rapid escape in any direction is possible from these vantage points and are used extensively by deer.

A2. Weakly Developed Soils, with Good Moisture Storage, on Decomposed Parent Material. There are only two major soils of this type: Barkerville (Granite), and Jayarr (Diabase).

These soils have good soil-moisture values to depths of about 4 feet and are capable of supporting a permanent herbaceous ground cover, or dense stands of chaparral.

Such soils which have developed on north slopes or wetter sites have a gravelly clay loam layer which makes them unusually productive. In spite of the poor soil development, the soil-water relationship is such that plants thrive on the soils.
Good water quality from these soils! Sulfate is 20-40 ppm. at 3 Bar.
These soils are well adapted to chaparral and, unless a high percentage of kill is obtained, tend to revert back to chaparral.

B. Where Grass Has Reached or Will Reach Climax. Moderately productive, moderately deep and deeply developed soils, with a distinct horizon of clay accumulation - examples of these chaparral soils are: Mt. Peeley, low elevation (schist); Cinnabar (schist); Showlow (old alluvium); Balon (old alluvium).

These are developed soils which have a distinct B horizon from 10-30" below the soil surface. Such soils are well suited to the production of grass, and due to the restricted downward movement of water are not the most desirable for the typically deep rooted chaparral. Chaparral that invades these grasslands due to fire, overgrazing, or extended drought tend to remain as stunted open stands with varying degrees of remnant grass depending upon the extensiveness of the root system of the existing chaparral.

Provided that (1) grazing management is maintained over domestic livestock, and (2) disturbance does not reoccur, this type has the greatest ability to persist as a grass and forb stand. Due to the clay layer, the plant-soil-water relationships are ideally suited to the production of grass. Such sites would be expected to be mid-grass climaxes.

These sites are ideally suited to grass; and, once total conversion has been accomplished, little maintenance is required. Provided that adequate management is maintained, the stand can go for extended periods of time without maintenance due to the low mobility of chaparral species. A combination of fire and heavy grazing will convert this type back to a chaparral stand. If heavily grazed, fire is not a serious problem.

These soils were typically grassland climaxes and never were, nor ever will be, climax chaparral, although mottes of chaparral originally occurred in them and was the source from which the type spread. Following disturbance of the grass cover, seed was carried by birds, animals, or washed down from above and became established. The typically deep rooted chaparral was incapable of penetrating the clay layer to any great degree; consequently, the stands never reached height that they did under the other principal soil conditions. The plants developed a more lateral root system and competed with one another. Combined with competition from the remnants of grass, the stands were never able to obtain the chaparral density that they did under the other soil conditions.

Chaparral stands on these soil situations eventually die out as single plants or in even aged clumps. Desert Ceanothus will be long gone before the manzanita starts to die off. (If past disturbance, fire and/or overgrazing has been alleviated, then grass occupies the area released from competition as this die out occurs. However, if the past disturbance was overgrazing, the situation has not been alleviated, and the stands will maintain themselves.) Generally speaking, these stands can be expected to revert to climax grassland eventually.

This relationship would provide a much more desirable quality (but lower quantity) of water than would "A" above, as the top layer of soil would absorb the water and ~~release it at a more desirable rate~~ retain dominant portion. Because of less slope, little erosion would be expected; thereby, providing less sediment and filtering out much of the high sulfate which is found in the Southwest.

This relationship is generally found as a grassland-chaparral savannah. This increase in interspersion makes these areas much more productive from a wildlife standpoint.

Where type A is predominantly used by deer, type B occupies many "bottom" situations and possesses a higher quality habitat for songbirds. However, the large oaks along these bottoms provide acorns which attract deer in large numbers during the fall and early winter. Where Gambel quail and javelina occupy the chaparral, they will most generally be found in this type.

C. Where Trees Have Reached or Will Reach Climax. Highly productive, deep, well-drained soils which possess a well developed B horizon - The principal soils in this group are Arp (schist), Jacks (sandstone), Gaddes (granite), Waldroup (cinders), Lonta (old alluvium), White House (old alluvium), Mt. Peeley, high elevation (schist), Workman (diabase), and Cherry Creek (arkosic sandstone).

These are well drained soils which have formed more or less in place and possess a well developed B horizon. The plant-soil-water relationship is ideal for growing many vegetation types. This is also the high water yield portion of the chaparral type. Following burning such sites develop into a mixed stand of dense, tall chaparral. Barring any further disturbance, such sites develop into open tree type chaparral with varying degrees of grass and forbs as understory dominated by tree oaks, Arizona cypress, Ponderosa pine or Douglas fir, with chaparral as an understory. As the overstory canopy becomes taller and increases in density, the understory is gradually shaded out.

Due to the soil-water relationships of these sites, nearly any vegetation will do well on them. Grass stands upon such sites are relatively stable from the standpoint of chaparral invasion from peripheral zones. Chaparral has a very low mobility and outward movement into pure grass and forb stands. Such sites, when in the proper precipitation zone would be expected to be a climax of higher life-form vegetation such as fir, pine, Arizona cypress, oak, or pinyon-juniper. Once a total conversion to grass has been achieved, these tree species would probably be the main invaders. Due to the plant-soil-water relationships, these soils are generally the primary water yielders when treated.

Once a total conversion to grass has taken place, periodic control will maintain the stand. However, since this is the most productive chaparral type, both from a water yield and forage production standpoint, it would be highly desirable to leave islands of the more desirable species or maintain an open savannah grassland. The latter can readily be achieved through the hand application of Fenuron. Although costly, the method is highly selective, and any given composition may be achieved to satisfy the ultimate objectives.

Two entirely different conditions presently exist on these soil situations.

1. Tree Climax (fir, ponderosa pine, Arizona cypress, pinyon-juniper). Many existing chaparral stands now occupy what was once a tree climax of one form or another. Wildfire destroyed the existing tree cover, and seed in the soil from preceding successional stages took over the site. On some tree sites, the preceding successional chaparral state was so ancient that few viable seed still existed. Fires on such sites were so hot as to virtually destroy the vegetation cover and allow for invasion of chaparral by the dissemination of seeds by birds and mammals. These sites, although dominated by tall, dense chaparral, are in some successional stage toward tree climax.

2. Latter successional stages of chaparral climax. Many such soil situations have either reached chaparral climax or are just entering the early successional stages to a tree climax. On such sites, there is evidence that soil development has reached the point where soil-water relationships favor trees. Scattered clumps or a thin cover of pinyon-juniper, Arizona cypress, or ponderosa pine, are just beginning to overtop the dominant chaparral.

As the stand opens up, grasses and forbs occupy the interspaces and gradually the understory. As the stand progressively opens up, trees (pinyon-juniper, Arizona cypress, ponderosa pine, or fir) emerge as individuals or small clumps. Gradually the trees overtop the chaparral which becomes understory. As the tree stand thickens and becomes taller, the chaparral is eventually shaded out and the site approaches a tree climax.

This relationship would provide the highest amount of water yield due to the deep soils and greater slope. Percolation of water into the soil would result in more springs, and, generally, a more permanent type stream flow in the canyon bottoms. With the exception of high intensity storms, very little erosion would be expected. This type would be expected to provide good water quality.

From a wildlife standpoint, this relationship's main contribution comes in the form of cover. Because of the excellent growing conditions, chaparral species rapidly grow out of reach from foraging animals. In addition, understory vegetation is rapidly shaded out. While forage characteristics of this site degrade, the cover factors improve. From a cover standpoint, this is very attractive to the illusive black bear as well as the deer.

PRETREATMENT RECOMMENDATIONS

1. Prior to treatment, a vegetation inventory of each area should be made to the standards outlined in the Range Environmental Analysis Handbook, FSH 2209.21, R-3. A map showing vegetation types and subtypes is essential for pretreatment planning. This inventory may also be used to help design future management by domestic livestock.

2. A comprehensive soil survey should be conducted to the standards outlined in FSH 2509.15. This information, together with the vegetation map listed above, will provide realistic information for treatment of any given area.

3. The existing species composition should be considered prior to initial treatment as well as the desired composition which may be achieved through maintenance.

4. Areas treated to achieve an overstory density of 50% or less should be maintained with a minimum of 15 to 20% of the composition desirable forage species. This may be achieved through the land application of Fenuron on types A and B.

5. That plant-soil-water relationships (types A, B, C) be used in determining areas to be treated.

6. Identify the wildlife species involved. Game and Fish Department specialist will be extremely helpful.

7. Run browse condition transects through proposed treatment areas. This will afford the following information:

a. Composition of stand.
b. Density of stand.
c. Use being made of stand.
d. Index to what animals are involved and relative abundance of each species.

8. Obtain recommendations from the State Game and Fish Department and Forest Service research biologist on treatment pattern most beneficial for wildlife.

9. Where quail habitat is involved (low fringed areas), make a quail call census. (This should be made during the peak of calling period. Dates available from the State Game and Fish Department.)

10. Where turkey habitat is involved (upper fringe areas), make a gobbler call census during the peak of breeding season. (Instructions available from Range and Wildlife Division, RO.)

11. Obtain list of nesting non-game birds using habitat type planned for treatment. Check list for rare, endangered or unique species involved.

12. Where live water is being produced, establish a water monitoring station when herbicides are to be used.

13. Attempt to determine how much of the original soil has been lost due to erosion under chaparral. This is important to determine if the same productivity can be expected or not.

14. With regard to guidelines for deer habitat preservation, the following were developed by the Arizona Game and Fish Department and the Rocky Mountain Forest and Range Experiment Station at Tempe, Arizona.

a. Strips are recommended since they provide the most "edge" between cover (standing brush) and feeding areas (openings).

b. Optimum size of opening should be approximately 30-35 acres. Beyond this, ability of deer to use the area decreases.

c. Optimum width of standing brush between openings should be approximately 1/4 mile. However, width may be as little as 1/8 mile if height and density of brush is adequate to provide security to deer.

d. An isolated patch of brush in an opening is not usable as cover if less than 20 acres in dense brush or less than 40 acres in sparse brush.

e. Any existing stands of large trees, such as riparian woodland, oak islands, or isolated pine or juniper stands, are important as bedding and resting areas for deer and should be maintained.

f. Brush surrounding watering places should be maintained as needed security for deer.

g. Shrub live oak is an important deer food plant and will provide important quantities of browse and mast if left in the openings.

h. With regard to guidelines for deer habitat improvement in connection with chaparral conversion, the following have special significance:

(1). Extremely dense stands of brush preserved for cover can be improved as habitat by thinning.

(2). Legumes and other forbs will improve forage conditions for deer if added to seed mixtures for converted areas.

MAINTENANCE RECOMMENDATIONS

1. Any given knoll, hill, or ridge may (and frequently does) have different soils with their related different vegetation on each of the different aspects. Although the parent material on all four aspects may be the same, the depth and development may be quite different. These differences must be considered when determining the type of maintenance to be performed.

2. Soil conditions (types A1, A2, B, C) should be the determining factors in pattern maintenance following broad scale burning.

3. The time of year is quite important in burning when using grass cover to carry fire. Burning at the wrong time will kill many grass species. Repeated burning at frequent intervals will seriously damage most grasses.
Burning Lehmann Lovegrass in February has been successful at S Bar.

4. If fire is to be used for maintenance of stand density, then grazing use must provide rest for vigor one year, production to carry fire one year, and rest following the fire.

5. The maintenance method selected should be directed toward maintaining a desirable species competition.

TREATMENT OF CHAPARRAL AREAS

I. Mechanical Methods

Good control of chaparral species by mechanical methods are limited to root plowing and treating with a brush rake. Both the above treatments are expensive and must be used on rock free areas with slopes of 20% or less. On suitable areas, the costs of rootplowing may be lowest in the long run – less hazard from erosion, chemicals, lower maintenance costs, etc.

By far the best opportunities in mechanical treatment present themselves in preparing the brush for selective use of fire. Such treatments as chaining, crushing, or chopping fall in this category.

SUMMARY

MECHANICAL METHODS FOR TREATING CHAPARRAL

METHOD	TYPE OF EQUIPMENT	TIME	TREATMENT INITIAL	TREATMENT MAINT.	LIMITATIONS	REMARKS
1. Chopping and Crushing	Martin Brush Cutter Fleco Brush Cutter	Any time when soil is not too wet to ball or puddle.	X		(1) Slopes 20% or less. (2) Areas w/50% or less surface rock with no large boulders.	Will not kill brush. A good method of reducing brush to allow selective burning.
	Heavy Roller	Any time	X		(1) Slopes 25% or less	(1) Since this is a rolling implement with no digging action, surface rock is not a limiting factor. (2) No initial brush kill (3) Use to reduce brush to allow selective burning.
	Tree Eater	Any time	X		(1) Slopes 20% or less (2) Rock free area.	(1) Reduces debris to shreads (2) Limited to special situations because of high cost and limited areas where it can operate.
2. Chaining	Chain at least 70 lbs/link. Preferable 2 to 3 chains with swivel hitches	Winter or before spring growth basins.	X		(1) Slope wherever tractors can operate.	(1) Can be used to reduce brush for selective burning.

METHOD	TYPE OF EQUIPMENT	TIME	TREATMENT INITIAL	TREATMENT MAINT.	LIMITATIONS	REMARKS
2. Chaining (Con't.)					(2) Where boulders will not prohibit tractor operation.	(2) Little initial brush kill.
					(3) Limited to mature stands. Chain will whip over young plants.	(3) Maintain constant speed of tractors where possible (2-3 miles per hour).
3. Raking	Fleco brush rake	Winter	X		(1) Slopes 20% or less	(1) This is essentially a land clearing operation. Some initial brush kill.
					(2) Will tolerate small amount of rock.	(2) Debris is windrowed and burnt.
						(3) This operation prepares a good seed bed.
4. Root Plowing	Root plow and D-8 or comparable tractor.	Winter and early spring.	X		(1) Limited to rock free areas slopes 20% or less.	(1) Good initial brush kill (60 - 80%).
						(2) Where brush is tall and dense, fire should precede root plowing for best results.
						(3) Very limited use in chaparral because of selective site.

II. Herbicides

Use Approval:

1. No herbicide will be used for any purpose whatsoever unless it is registered for the use to which it will be put.

2. Rates of application of a herbicide will not exceed rates shown on the label. The method of application and carrier used will be in accordance with the safest methods for a specific situation and based on the latest technical information available.

3. The use of all herbicides will be approved by the Regional Forester.

4. All herbicide projects must be submitted to the Regional Pesticide Committee for screening and inclusion in the Regional herbicide program.

Application of Herbicides

Chaparral areas are best suited to helicopter application. Because of terrain and dense brush, the use of flagmen is impractical. Areas to be sprayed should be shown to the pilot at least daily and boundaries of units marked from the air with paper streamers.

Fuel break areas next to open water and other critical areas can generally be sprayed best with ground equipment. There are several trailer type sprayers which are pulled with a prime mover. On rough terrain and where the brush is dense and tall, a spray unit with saddle mounted tanks has been designed for track tractors.

Because of the higher volumes of total solution applied per acre, application with a ground rig constantly gives better kills of brush as compared to aerial application.

Safety - Aerial Application

1. Do not approach aircraft until pilot signals. Approach helicopter only from front.

2. Wind sock should be posted at loading area.

3. Only one person should work on a hopper at one time. Work only from the ground. Do not stand on helicopter skids to load hopper.

4. Fire extinguisher and first aid kit should be available at the loading area.

5. Tanks must be constructed for bottom loading.

6. Personnel at helispot must wear goggles and hardhats with chin straps.

7. Keep aircraft in signt at all times when it is working on the project.

Supervision in Application - Aerial Application

Instructions for Project Supervisors:

1. Inspect area with successful bidder prior to start of spraying. Make applicator aware of sensitive areas, terrain, and any hazards which may be encountered in application of the spray.

2. Check all ground equipment, tanks, mixers, pumps, and put in first class condition.

3. Check calibration of aircraft prior to starting work.

4. Train ground crew in advance of spraying and see that tasks are performed during spray operations.

5. Check mixing of herbicides.

6. Obtain one pint sample of herbicide concentrate from each barrel used. Use glass jars for samples.

7. Keep check on weather conditions and shut down operations according to terms of contract.

8. Arrange for placement of spray sensitive cards to check for draft droplet size and skips in coverage of spray area.

9. Enforce safety regulations at all times.

Weather Conditions

1. No aerial application of a conventional herbicide spray will be made when wind speed is greater than 5-7 miles per hour.

Invert applications will not be made when wind velocities exceed 10 miles per hour.

2. No aerial application of a conventional herbicide spray will be made when temperatures exceed 80° F.

Invert applications will not be made when temperatures exceed 90° F.

3. Thermos or inversions may occur at temperatures lower than the maximum temperatures for spraying (2 above). When such conditions occur, no spraying will be done.

4. No spraying will be done during rainy or foggy weather. Allow one hour after a rainstorm before continuing spraying.

Handling of Herbicides and Containers

1. Store all herbicides in original containers. Keep out of reach of children, pets, and livestock.

2. Keep all herbicides away from food, foodstuffs, and grass seed.

3. Read the entire label on herbicide container and follow directions.

4. Avoid inhaling herbicide sprays or dust when mixing or applying them.

5. Avoid spilling herbicide on skin or clothing. If spilled, wash off immediately with soap and water. Clothing wet with spray material should be removed at once.

6. Do not eat or smoke while working directly with herbicides.

7. Discard any herbicide container without label or damaged label. Do not guess at contents.

8. Be careful in filling or emptying spray equipment, especially on sloping ground to avoid contaminating streams or bodies of water.

9. Destroy all empty herbicide containers and bury them.

Formulations, Rates, and Time of Application

1. 2,4-D and 2,4,5-T. Large scale projects have used 2,4-D and 2,4,5-T in combination. Results to date indicate that a combination of 1 pound acid equivalent of low volatile ester 2,4-D plus 1 pound acid equivalent of low volatile ester of 2,4,5-T mixed with a cup of detergent, two quarts of diesel, and enough water to make a total solution of 8 gallons applied to one acre has been the most effective and economical mixture. Turbinella oak is the most difficult plant to kill. Three to four repeated sprayings will give good control using the above formulation.

Applications of 2,4-D and 2,4,5-T have been made in the invert form. No difference in kill is detected between invert and conventional applications. Drift was reduced by invert application when wind velocities exceeded 5 miles per hour. Applications of 2,4-D and 2,4,5-T can be made both spring and fall. Results seem to be about the same. The important point is to apply this herbicide when the plant growth is vigorous. Vigorous growth is more consistent in the spring. For this reason, spring is probably the best time to apply these herbicides. Growth is usually at its greatest between May 1-15.

Greater selectivity is obtained with fall spraying due to the difference in growth rates at this time. Fall treatments do very little damage to hollyleaf buckthorn while oak and manzanita are badly damaged.

2. Fenuron (25% active). Fenuron was applied at rates of 32 and 64 pounds total material per acre. The heavier rate is very effective, producing the best kill of any herbicide applied. If the price of this material is greatly reduced, it could well become a standard one-shot treatment. Present cost range from $65 to $93 per acre. Fenuron can be applied by either a ground crew or by helicopter equipped with a seeding attachment. Applications of Fenuron should be made during the late fall and winter period. There is no evidence that Fenuron interfers with the growth of native or seeded grasses and forbs when applied to decomposed granite soils. Fenuron is a broad-spectrum herbicide, and will kill grass as well as forbs and shrubs. At high application rates, it can be expected to inhibit grass establishment for up to 18 months after placement.

SUMMARY

CHEMICAL METHODS FOR TREATING CHAPARRAL

METHOD	TYPE OF EQUIPMENT	TIME	TREATMENT INITIAL	TREATMENT MAINT.	LIMITATIONS	REMARKS
1. Aerial Conventional Application (Spray)	Helicopter	Spring - May 1-15 or Fall - Aug. 15 - Sept. 1 Sprouts should be at least 36" tall.		X	(1) Apply when wind velocity is less than 5 mi. per hr. (2) Watch for thermos shut down when spray is not settling to ground. See narrative for limitations applying to all herbicides.	FORMULATIONS L.V. ester 2,4-D L.V. ester 2,4,5-T Silvex HERBICIDE RATES 2# acid equivalent per acre for any single formulation or combinations of above formulations. CARRIER 1 cup of detergent 2 quarts of diesel plus water added to herbicide to make 8 gallons. APPLICATION RATE OF HERBICIDE PLUS CARRIER (TOTAL SOLUTION) 8 gallons per acre.
2. Aerial invert application (Spray)	Helicopter equipped to apply invert emulsions	(Same as conventional)		X	Wind velocity maximum 10 mi. per hour. Thermo's not as critical with invert.	Inverts when applied in right manner will eliminate drift. Comparable kills have been obtained in chaparral. Cost per acre is about 1/4 greater with inverts. Same formulations and rates are used in conventional above.

METHOD	TYPE OF EQUIPMENT	TIME	TREATMENT INITIAL	TREATMENT MAINT.	LIMITATIONS	REMARKS
3. Aerial Hydro foil applica-tion (Spray)	Helicopter equipped with hydro foil boom	Spring - May 1-15 or Fall - Aug. 15 - Sept. 1 Sprouts should be at least 36" tall.		X	Wind velocity maximum 10 mi. per hour. Thermos not a factor.	Same formulation and rates as conventional. Boom is so constructed that no droplets smaller than 1400 microns are formed. Spray looks like a sheet of water coming down to ground.
4. Aerial Fenuron (Pellets)	Helicopter with seeding attachment. Can also be applied by ground crew	Late fall or winter Do not apply when ground is frozen.		X	Fenuron is applied in pellet form so wind and temperature are not limiting factors. Can be applied when it is safe to fly a heli-copter. Do not apply in damp or rainy weather.	Formulation 25% active ingredients. Rate 60#/acre.
5. Ground applica-tion Mountainous terrain	Ground spray Rigs equipped with boom	Spring - May 1-15 or Fall - Aug. 15 - Sept. 1		X	Wind velocity maximum 10 mi. per hour	Same herbicide and rates as for conventional spray. Carrier: 1 cup of detergent, 2 qts. of diesel plus water added to make 20 gallons. Application of a total solu-tion of 20 gallons per acre.

III. Seeding

Competition of grass for soil moisture will reduce the total brush seedlings, but some seedlings always survive. Grass competition does not kill brush sprouts - the dominant regrowth in chaparral. Perennial grasses, usually recommended for sowing, are not competitive the first year. Herbicide applications should be used to kill the first crops of brush seedlings. Then competition from a full grass cover will limit reinvasion of brush seedlings. Thus, grass competition is an essential control measure in the long-term maintenance of a converted area (Bentley, 1967).

Fall burning, followed by chemical spraying the next spring, offers the advantage of less vigorous regrowth and may have practical application in chaparral management (Lillie, et al, 1964).

Some grass production may be obtained from seeding weeping lovegrass in areas where reduction of oak cover is slight. However, to obtain good stands and high production, more than half of the oak canopy should be eliminated (Pond, 1961).

Ungrazed stands of weeping lovegrass begin to deteriorate a few years after treatment. The decline does not appear to be related to brush cover or precipitation (Pond, 1968). The establishment of a variety of grass and forb species in converted acreages would be preferred over a solid stand of any single species. "A Comparison of 16 Grasses and Forbs for Seeding Chaparral Burns" (~~Lanier~~ and Pase, 1963) was a good piece of work and more work of this type is needed.

Very little opportunity exists to place seed in the ground with a drill in the chaparral zone. The most practical method of seeding is by broadcasting either aerial or ground.

Broadcasting

Broadcasting of seed either by aerial or ground operation has been successful when competing vegetation has been eliminated either by mechanical methods or use of fire. Under some conditions, it is necessary to use a method of covering the seed after it has been broadcast.

Small seeded species lend themselves to broadcast seeding much better than large seeded species, simply because small seeds are covered by natural ~~sluff~~. Under severe conditions, some type of a mulch has been found beneficial to use in connection with broadcast seeding. Limitations to broadcast seeding are:

1. Requires heavier seeding rates.

2. Covering of seed is poor, compared to drilling.

3. Distribution of seed is often poor.

4. Loss of seed to insects and rodents is great.

5. Establishment is often slower.

The following is a list of points which must be taken into consideration when planning and accomplishing seeding with aircraft.

Planning Seed Needs

To determine the amount of seed needed for the total project, use gross acreage. It is cheaper to seed gross area than it is to try to avoid islands and other areas that you do not necessarily want to seed. If the terrain is rough and the area has uneven edges, figure seed needs on gross acres plus 10%.

Preparation Prior to Aerial Seeding

1. Mix seed prior to scheduled aerial application.

2. Weigh and mark weight on each sack of mixed seed. Each sack should not weigh over 50 pounds. Weights are used to pre-group each load prior to actual loading operations and also to keep an estimate of seed being applied per acre.

3. Arrange for pilot to fly a reconnaissance of area to acquaint himself with area and feel out terrain and air conditions.

4. Locate helispots so that seeding can be accomplished with minimum of ferry time. Generally, one helispot per 1000 acres is sufficient. However, this will vary with layout of area to be seeded.

5. Keep seed dry. If there is a chance of rain, do not leave seed in field overnight; or provide for covering with rainproof material.

Procedure During Seeding Operation

1. Calibration of seeding rate. Place cardboard cards, one foot square, perpendicular to line of flight about 10 feet apart. Cover the cards with a light grease. Seed will stick to the greased cards. The number of seeds on each card can be counted and applied back to the desired number of seeds per square foot. The greased cards will also help determine the distribution of seed and the effective swath width.

In addition, a further determination for calibration can be made by establishing a check area of a given acreage. Let the pilot fly until he has covered about half the known acreage. Check the hoppers and adjust accordingly. This may have to be repeated a couple of times.

2. Make first seeding pass around exterior boundaries of area. This will assure seed coverage for the edges and facilitate turn-around efforts for the helicopter.

3. Fly grids against or with wind. Do not fly cross wind unless absolutely necessary.

When flying with or against wind, flight time per day can be extended considerably.

4. Flights should start as early as possible, just as soon as there is light enough for safe flight. Normally, this is the quiet time of day.

5. Winds will dictate the duration of operation in any one day. Do not seed in winds in excess of 15 miles per hour.

6. Keep track of pounds of seed and acreage covered as a check on distribution of seed and calibration of helicopter.

Procedure after Seeding Operation

1. Clean up all loading areas including sacks and loose paper.

2. Seed with poison on it should be removed from loading area and destroyed.

3. Cards used for seed counts should be removed from the field.

SPECIES SELECTION CHAPARRAL AREA

This area includes our heavy brush type consisting of turbinella oak, manzanita, mountainmahogany, skunkbush and associated species. The ecology of much of this area is brush. Only on ~~the~~ certain soils is there a reasonable chance of establishing and maintaining grass on a permanent basis. Soils should be at least 20" in depth and not have over 50% rock in the soil profile.

SPECIES	ELEVATIONAL RANGE		
	UNDER 4500 FT.	4500-6000 FT.	OVER 6000 FT.
LEHMANN LOVEGRASS	X		
WEEPING LOVEGRASS		X	X
BOERS LOVEGRASS	X	X	
SAND DROPSEED			X
TURKESTAN BLUESTEM		X	X
KING RANCH BLUESTEM	X		
BUSH MUHLY	X		
SIDE OATS GRAMA		X	
BLUE PANIC (AREAS RECEIVING ADDITIONAL MOISTURE)	X		
WESTERN WHEATGRASS (ON CLAY SOILS)		X	X
SMILO (AS A TRIAL)	X	X	X
HARDING GRASS (AS A TRIAL)	X	X	
CICER MILKVETCH		X	

(See FSH 2209.23 for mixtures and rates of seeding)

SEMI DESERT GRASSLAND

SPECIES SELECTION

This is the hot and dry grassland areas of the Lincoln, Gila, Coronado and Tonto Forests. Mesquite and creosote brush have increased on many acres of these grasslands.

SPECIES	SOIL TEXTURE GROUPS		
	SANDY	LOAM	CLAY
Black Grama		X	
Sideoats Grama		X	X
Blue Grama		X	X
Lehmann Lovegrass	X	X	
Boers Lovegrass	X	X	
Plains Lovegrass	X	X	
Alkali Sacaton			X
Vine Mesquite		X	X
Sand Dropseed	X		
Bush Muhly	X	X	
Plains Bristle	X	X	

(See FSH 2209.23 for mixtures and rates of seeding)

SOME CHAPARRAL PUBLICATIONS

BAUER, HARRY L. 1943. The statistical analysis of chaparral and other plant communities by means of transect samples. Ecology 24:45-60.

BENTLEY, JAY R. 1967. Conversion of chaparral areas to grassland: Techniques used in California. U.S.D.A., Agric. Handbook #328. 35 pp., illus.

BISWELL, H. H., R. D. TABER, et al. 1952. Management of chamise brushlands for game in the Norch Coast Region of California. California Game and Fish Vol. 38(4): 482-483.

BISWELL, H. H. and J. H. GILMAN. 1961. Brush management in relation to fire and other environmental factors on the Tehama deer winter range. California Fish and Game. 47(4): 357-389, illus.

CABLE, DWIGHT R. 1957. Chemical control of chaparral shrubs in central Arizona. J. Forest. Vol. 55(12): 899-903.

_____, 1957. Recovery of chaparral following burning and seeding in central Arizona. Rocky Mtn. Forest & Range Exp. Sta. Res. Note No. 28. 6 pp.

CHAPLINE, WILLIAM R., and MURREL W. TALBOT. 1959. An evaluation of the effects of fire on watershed values of ponderosa pine and chaparral lands of the Salt River Watershed. (Typed Report) Watershed Management Consultants, Charles Lathrop Pack Forestry Foundation.

CROXEN, FRED W. 1926. History of grazing on Tonto National Forest. Paper presented by Senior Forest Ranger Fred W. Croxen at the Tonto Grazing Conference in Phoenix, Arizona, November 4-5, 1926. Mimeo. 15 pages.

DAVIS, EDWIN A. 1959. Laboratory and greenhouse investigations on the chemical control of chaparral. IN: Watershed Management Research in Arizona. Rocky Mountain Forest & Range Exp. Sta. Progr. Rep. 1959. pp. 47-52.

_____, 1961. Effectiveness of soil-herbicide irrigation treatments for the control of shrub live oak in Arizona. Western Weed Contr. Conf. Res. Progr. Rep. 1961: 20-22.

_____, 1961. Evaluation of several granular and pelleted herbicides in the greenhouse for control of shrub live oak. Western Weed Contr. Conf. Res. Progr. Rep. 1961: 19-20.

_____, 1961. Research on the chemical control of shrub live oak. Pacific Southwest Inter-Agency Comm. Meeting. March 10, 1961. 6 pp. (mimeo)

_____, 1964. Picloram: A promising brush control chemical. U. S. Forest Service Res. Note RM-35. 2 pp.

_____, 1965. The mechanism of fenuron injury to plants. U.S. Forest Service Res. Note RM-50. 2 pp.

_____, 1966. The role of starvation in fenuron injury to shrub live oak. Weeds 14(1): 10-16.

_____, and CHARLES P. PASE. 1969. Selective control of brush on chaparral watersheds with soil-applied fenuron and picloram. U.S. Forest Service Res. Note RM-140, 4 pp.

_____, P. A. INGEBO, and C. P. PASE. 1968. Effect of a watershed treatment with picloram on water quality. U. S. Forest Service Res. Note RM-100. 4 pp.

DAVIS, JAMES R. 1968. Freeze drying for preparing Arizona chaparral plants for energy analysis. Rocky Mtn. Forest & Range Exp. Sta. U. S. Forest Service Res. Note RM-106. 2 pp.

GALLIZIOLI, STEVE. 1956. Ecological investigation of Prescott Study Area. IN: Arizona Chaparral Deer Study. Job Completion Reports, Project W-71-R-3, 1955, WP4-J2, Arizona Game & Fish Dept. 8 pp.

_____, 1956. Field observations of deer in the Prescott Study Area. IN: Arizona Chaparral Deer Study. Job Completion Reports, Project W-71-R-3, 1955. WP3/J1, Ariz. Game & Fish Dept. 16 pp.

_____, 1958. Deer carrying capacity of various sub-types within the chaparral habitat. Arizona Game & Fish Dept., W-78-R-2, WP5/J1. 4 pp. (mimeo)

_____, 1959. Deer carrying capacity of various sub-types within the chaparral habitat. IN: Arizona Game Studies 1958. Ariz. Game & Fish Dept. W-78-R-3, WP5/J1. 3 pp.

GARCIA, R. M., and C. P. PASE. 1967. Moisture-retention capacity of litter under two Arizona chaparral communities. U. S. Forest Service Res. Note RM-85. 2 pp.

GLENDENING, GEORGE E. 1959. Watershed management research in the chaparral type. IN: Watershed Management Research in Arizona. Rocky Mtn. Forest & Range Exp. Sta. Progr. Rep. 1959. pp. 31-43.

_____, 1959. Watershed management research in the chaparral type. IN: Watershed Management Research in Arizona. Rocky Mtn. Forest & Range Exp. Sta. Progr. Rep. 1959. pp. 33-43.

_____, C. P. PASE, and P. INGEBO. 1961. Preliminary hydrologic effects of wildfire in chaparral. IN: Modern Techniques in Water Management, Proceedings, Fifth Annual Arizona Watershed Symposium, Sept. 21, 1961.

HASTINGS, JAMES RODNEY. 1959. Vegetation change and arroyo cutting in southeastern Arizona. Jour. Arizona Academy of Science. 1(2): 60-67.

INGEBO, PAUL A. 1969. Effect of heavy late-fall precipitation on runoff from a chaparral watershed. U. S. Forest Service Res. Note RM-132, 2 pp.

JANTZEN, ROBERT A. 1959. The effect of brush manipulation upon watershed management. IN: Arizona Game Studies 1958. Arizona Game & Fish Dept. W-78-R-3, WP5/J1. 4 pp.

LAVIN, FRED and CHARLES P. PASE. 1963. A comparison of 16 grasses and forbs for seeding chaparral burns. U. S. Forest Res. Note RM-6, 4 pp. Rocky Mtn. Forest & Range Exp. Sta.

LILLIE, DONALD T. 1959. Field investigations on the chemical control of chaparral. IN: Watershed Management Research in Arizona. Rocky Mtn. Forest & Range Exp. Sta. Progr. Rep. 1959. pp. 55-63.

_____, 1962. Control of shrub live oak (Quercus turbinella Greene) with granular and pelleted herbicides. Western Weed Contr. Conf. Res. Progr. Rep. 1962: 16.

_____, 1962. Herbicide combinations for the control of shrub live oak. Res. Progr. Rep. Western Weed Contr. Conf. Proc. 1962: 17-18.

_____, 1963. Control of Arizona chaparral with 2,4,5-T and silvex. J. Range Manage. 16: 195-199.

_____, and E. A. DAVIS. 1961. Chemicals for control of chaparral. Modern Techniques in Water Management Proc. 5th Annual Arizona Watershed Symp. Sept. 21, 1961.

_____, G. E. GLENDENING, and C. P. PASE. 1964. Sprout growth of shrub live oak as influenced by season of burning and chemical treatments. J. Range Manage. Vol. 17(2): 69-72.

LINDENMUTH, A. W., JR., and JAMES R. DAVIS. 1962. Chemical treatment helps burn brush safely in Arizona. The Timberman 43(7): 9.

_____, and G. E. GLENDENING. 1962. Controlled burning of Arizona chaparral a 1962 progress report. Ariz. Watershed Program. Proc. 6th Annual Watershed Symp. Sept. 18, 1962.

MC CULLOCH, CLAY Y. 1955. Ecological investigation of Three Bar study area. IN: Arizona Chaparral Deer Study. Job Completion Reports, Project W-71-R-3, 1955, WP4/J1, Ariz. Game & Fish Dept., 11 pp.

_____, 1955. Field observations of deer in the Three Bar vicinity. IN: Arizona Chaparral Deer Study. Job Completion Reports, Project W-71-R-3, 1955. WP3/J1. 10 pp.

_____, 1955. The investigation of penned deer in chaparral habitat. IN: Arizona Chaparral Deer Study, Job Completion Reports, Project W-71-R-3, 1955. WP5, Ariz. Game & Fish Dept. 3 pp.

_____, 1959. The effect of brush manipulation upon watershed management. UB: Wildlife Research in Arizona 1959. Ariz. Game & Fish Dept. W-78-R-4, WP5/J2. 5 pp.

_____, 1961. The effect of brush manipulation upon Watershed Management. IN: Wildlife Research in Arizona 1960. Ariz. Game & Fish Dept. W-78-R-5, WP5/J2. 11 pp.

_____, 1962. The effect of brush manipulation upon watershed management. IN: Wildlife Research in Arizona 1961. Ariz. Game & Fish Dept. W-78-R-6, WP5/J2. 6 pp. (mimeo)

_____, 1963. The effect of brush manipulation upon watershed management. IN: Wildlife Research in Arizona. 1962. Ariz. Game & Fish Dept. W-78-R-7, WP5/J2. 23 pp.

_____, 1964. The effect of brush manipulation upon watershed management. IN: Wildlife Research in Arizona 1963. Ariz. Game & Fish Dept. W-78-R-8, WP5/J2. pp. 93-100.

_____, 1965. Habitat manipulation in chaparral vegetation. IN: Wildlife Research in Arizona 1964. Ariz. Game & Fish Dept. W-78-R-9, WP5/J2, pp. 159-164.

_____, 1966. Habitat manipulation in chaparral vegetation. IN: Wildlife Research in Arizona 1965. Ariz. Game & Fish Dept. W-78-R-10, WP5/J2. pp. 85-111.

_____, 1967. Habitat manipulation in chaparral vegetation. IN: Wildlife Research in Arizona 1966. Ariz. Game & Fish Dept. W-78-R-11, WP5/J2/63-76.

_____, 1968. Habitat manipulation in chaparral vegetation. IN: Wildlife Research in Arizona 1967. Ariz. Game & Fish Dept. W-78-R-12, WP5/J2, pp. 73-76.

_____, 1969. Effect of chemical brush control on deer distribution. IN: Wildlife Research in Arizona 1968. Ariz. Game & Fish Dept. pp. 157-162.

_____, 1969. Seasonal food preferences of deer in chaparral. IN: Wildlife Research in Arizona 1968. Ariz. Game & Fish Dept. W-78-R-13, WP4/J9, pp. 163-166.

NICHOL, A. A. 1937. The natural vegetation of Arizona. Univ. of Ariz. Coll. of Agr. Agr. Exp. Sta. Tech. Bull. No. 68, pp. 181-222.

_____, 1952. The natural vegetation of Arizona. Univ. of Ariz. Ariz. Agr. Exp. Sta. Tech. Bull. No. 127, pp. 187-230.

PASE, CHARLES P. 1965. Shrub seedling regeneration after controlled burning and herbicidal treatment of dense Pringle manzanita chaparral. U. S. Forest Service Res. Note RM-56. 2 pp.

_____, 1966. Grazing and watershed value of native Arizona plants. IN: Native plants and animals as resources in arid lands of the southwestern United States. Amer. Assoc. Advance. Sci., Rocky Mtn. & Southwest Div. Contrib. i: 31-40. 1966.

_____, 1967. Helicopter-applied herbicides control shrub live oak and birchleaf mountain mahogany. U. S. Forest Serv. Res. Note RM-84. 4 pp.

_____, 1969. Survival of Quercus turbinella and Quercus emoryi seedlings in an Arizona chaparral community. The Southwest Naturalist 14(2): 149-155.

_____, and MARTIN M. FOGEL. 1967. Increasing water yield from forest, chaparral, and desert shrub in Arizona. International Conf. on Water for Peace Proc., Vol. 2, pp. 753-764.

_____, and GEORGE E. GLENDENING. 1965. Reduction of litter and shrub crowns by planned fall burning of oak-mountainmahogany chaparral. U. S. Forest Serv. Res. Note RM-49.

_____, and P. A. INGEBO. 1965. Burned chaparral to grass: early effects on water and sediment yields from two granitic soil watersheds in Arizona. Proceedings of the Arizona Watershed Symposium, Sept. 22, 1965, Tempe.

_____, and R. ROY JOHNSON. 1968. Flora and vegetation of the Sierra Ancha Experimental Forest, Arizona. USDA-Forest Service Res. Pap. RM-41. 19 pp.

_____, P. A. INGEBO, E. A. DAVIS and C. Y. MC CULLOCH. 1967. Improving water yield and game habitat by chemical control of chaparral. International Union Forestry Res. Organization. XIV. IUFRO-Kongress, v. I, Sect. 01-02-11, pp. 463-486.

_____, and FLOYD W. POND. 1964. Vegetation changes following the Mingus Mountain burn. U. S. Forest Service Res. Note RM-18.

_____, 1970. Personal communication.

POND, FLOYD W. 1961. Basal cover and production of weeping lovegrass under varying amounts of shrub live oak crown cover. J. Range Manage. 14(6): 2 pp.

_____, 1961. Mechanical control of Arizona chaparral and some results from brush clearing. IN: Modern Techniques in Water Management. Proc. Fifth Annual Ariz. Watershed Sumposium, Sept. 21, 1961 pp. 35-41.

_____, 1964. Response of grasses, forbs, and halfshrubs to chemical control of chaparral in Central Arizona. J. Range Manage. 17(4): 200-203.

_____, 1967. Grazing values on undisturbed chaparral versus areas converted to grass: the Tonto Springs range. USDA Forest Service Rocky Mtn. Forest & Range Exp. Sta. 14 pp.

_____, 1968. Changes in grass production on ungrazed converted chaparral. U. S. Forest Service Rocky Mtn. Forest & Range Exp. Sta. Res. Note RM-98, 4 pp.

_____, 1969. Grazing values on undisturbed chaparral versus areas converted to grass. Rocky Mtn. Forest & Range Exp. Sta. 13 pp.

_____, and D. R. CABLE. 1960. Effect of heat treatment on sprout production of some shrubs of the chaparral in central Arizona. J. Range Mange. 13: 313-317.

_____, and _____. 1962. Recovery of vegetation following wildfire on a chaparral area in Arizona. USDA Forest Service Rocky Mtn. Forest & Range Exp. Sta. Res. Note No. 72. 4 pp.

_____, D. T. LILLIE, and H. R. HOLBO. 1965. Shrub live oak control by root plowing. U. S. Forest Service Res. Note RM-38.

REYNOLDS, HUDSON G. 1958. Vegetational types in Arizona, in relation to grazing use. Ariz. Cattlelog 13(5): 26-27.

_____, 1967. Chemical constituents and deer use of some crown sprouts in Arizona chaparral. J. Forestry Vol. 65(12): 905-907.

_____, and G. E. GLENDENING. 1959. Research in management of chaparral lands in Arizona. Ariz. Cattlelog 14(12): 13-16.

_____, and R. ROY JOHNSON. 1964. Habitat relations of vertebrates of the Sierra Ancha Experimental Forest. U.S. Forest Service Res. Paper RM-4. 16 pp.

RICH, LOWELL R., and HUDSON G. REYNOLDS. 1963. Grazing in relation to runoff and erosion on some chaparral watersheds of central Arizona. J. Range Manage. 16(6): 322-326.

SAUNIER, R. E. and R. F. WAGLE. 1967. Factors affecting the distribution of shrub live oak. (Quercus turbinella Greene). Ecology 48(1): 35-41.

SCHMUTZ, ERWIN M. and TURNER, RAYMOND M. 1957. Herbicide tests on fire sprouts of turbinella oak in the Arizona chaparral. Res. Progr. Rpt., West. Weed Control Conf. Proc. 1957: 44.

_____, and D. W. WHITMAN. 1962. Shrub control studies in the oak-chaparral of Arizona. J. Range Manage. 15: 61-67.

SWANK, WENDELL G. 1958. The mule deer in Arizona chaparral. Ariz. Game & Fish Dept. Wildl. Bull. No. 3, 109 pp.

_____, and STEVE GALLIZIOLI. 1956. State-wide reconnaissance of chaparral deer ranges. IN: Arizona Chaparral Deer Study, Job Completion Reports, Project W-71-R-3, 1955, WP7/J1. Ariz. Game & Fish Dept. 5 pp.

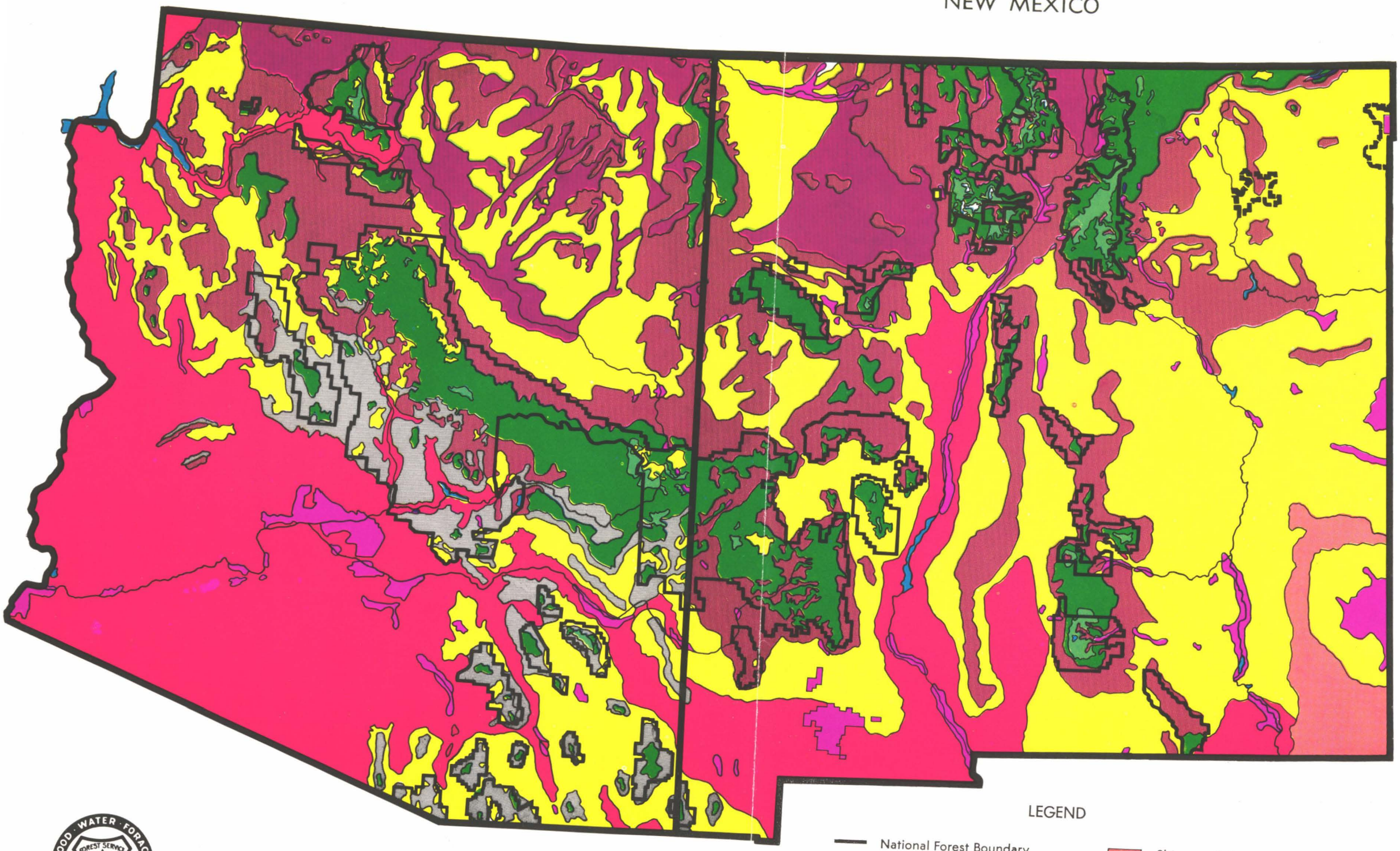
TABER, RICHARD D. and RAYMOND F. DASMANN. 1958. The black-tailed deer of the chaparral. -- Its life history and management in the north coast range of California. State of Calif. Dept. of Fish & Game, Game Management Branch, Game Bull. No. 8.

TIEDEMANN, ARTHUR R. and ERWIN M. SCHMUTZ. 1966. Shrub control and reseeding on the oak chaparral of Arizona. J. Range Manage. 19: 191-195.

VEGETATIVE COVER TYPES

ARIZONA

NEW MEXICO



LEGEND

- National Forest Boundary
- National Grassland Boundary
- Mixed Conifer
- Ponderosa Pine
- Pinyon — Juniper
- Chaparral
- Shinnery Oak
- Northern Desert Shrub
- Hot Desert Shrub
- Grassland
- Irrigated Lands
- Alpine Tundra
- Lakes & Reservoirs

WOOD · WATER · FORAGE · WILDLIFE · RECREATION

FOREST SERVICE U S DEPARTMENT OF AGRICULTURE

U. S. Department of Agriculture ★ Forest Service – Southwestern Region